

Mesoscale Circulation and Primary Production in Eastern Boundary Current Systems

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LONG-TERM GOALS

The long-term goals of this project are to: (1) improve our ability to measure the patterns of primary production and phytoplankton abundance in the ocean, (2) understand what causes these patterns and (3) improve our predictive ability.

OBJECTIVES

Patterns of primary production and phytoplankton abundance in the ocean are obscured by the great spatial and temporal variability. We are attempting to better resolve spatial pattern by using a continuous underway mapping system, and temporal pattern by additional shipboard sampling, analysis of coastal shore station data and model output to fill in the gaps between shipboard surveys. We have shown that physical structure which determines the nutrient distribution and advection are the two main determinants of phytoplankton abundance in the California Current. We are now attempting to determine which specific aspects of physical structure have the most direct effect upon phytoplankton abundance. Prediction is hindered by our ability to predict either physical or biological structure, and by our limited understanding of how physical and biological structure are linked. We expect that progress will come most rapidly in predicting physical structure. We are thus attempting to predict the patterns of phytoplankton given predictions of physical structure.

APPROACH

Analysis of continuous underway data has focused upon testing predictions based upon the expected linkages between physical and biological structure (e.g., the temperature-nitrate relation and the temperature-chlorophyll relation). The finding of some unexpected patterns (e.g., high chlorophyll at temperatures where nitrate is not expected to be present) has led to a better understanding of the regional nature of the linkages between physical and biological structure. Analysis of historical data indicates that the linkages between physical and biological structure also depend upon the temporal scale of physical forcing. This analysis has focused upon mesoscale, seasonal, and interannual to decadal scale forcing. It is not clear that linkages determined on one space-time scale will apply to others, and we are determining to what extent linkages are scale dependent. Collaborations with programs developing physical models of the regional circulation will lay the groundwork for making predictive models of ecosystem structure.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 1998		2. REPORT TYPE		3. DATES COVERED 00-00-1998 to 00-00-1998	
4. TITLE AND SUBTITLE Mesoscale Circulation and Primary Production in Eastern Boundary Current Systems				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of California, San Diego, Scripps Institution of Oceanography, 9500 Gilman Dr, La Jolla, CA, 92093-0218				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM002252.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 3	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

WORK COMPLETED

We have completed development of a data processing scheme for the continuous underway mapping system and have improved the reliability of data logging software. Work is continuing on a data management scheme and processing data from past cruises. A manuscript on the continuous underway data and linkages between physical and biological structure is in press. We have provided interpretation of CalCOFI and other regional data in support of ONR projects collaborating with the CalCOFI program. We have collected and processed continuous underway data on an additional series of cruises (shiptime and hydrographic data collection supported by UC resources and NOAA) which give use monthly coverage of a subset of the CalCOFI grid during the El Niño period from October 1997 to January 1999. We have gathered the historical chlorophyll data from the California Current region for comparison with the hydrographic and macrozooplankton time series.

RESULTS

Analysis of a 4-year time series of continuous underway data in the context of hydrographic data shows that there is a variable relation between nearsurface physical structure (temperature, salinity) and chlorophyll in different subregions of the California Current. The boundaries of these subregions (regimes) can be identified based upon physical structure. Analysis of the hydrographic data gives insights into the differing types of physical forcing which determine phytoplankton abundance in each subregion. Analysis of the chlorophyll time-series does not show the same large decline since the mid-1970s as has recently been documented for macrozooplankton biomass. Although the chlorophyll time series has many fewer data points and it is not as long as the macrozooplankton time series (chlorophyll began as a routine measurement in 1984), this leads to the question of whether climate change affects the lower trophic levels in the California Current via bottom-up forcing. Analysis of the monthly coverage during the El Niño period shows that vertical temperature structure and the mesoscale circulation patterns can change very rapidly in the region. Changes in the circulation pattern can be predicted from mesoscale resolving models when properly initialized with regional data. Pattern in biological structure is strongly related to pattern in physical structure.

IMPACT/APPLICATION

The observation that nearsurface physical-biological coupling is region specific and that the boundaries between regions can be identified based upon physical structure, means that it may be possible to start developing region-specific models linking physical and biological structure. The observation of rapid changes in physical and biological structure in this system illustrates the potential value of mesoscale resolving physical models in predicting biological structure. Uncertainty about whether the decline in macrozooplankton biomass is due to bottom-up forcing further illustrates the need to better understand the processes linking physical and biological structure.

TRANSITIONS

A major objective of this project is identify those specific aspects of physical structure which can be modeled or remotely sensed which have the most predictive value about the phytoplankton distribution. Identifying these properties should have value in focusing observational and modeling efforts in support of biological objectives and in improving our ability to describe and predict biological structure.

RELATED PROJECTS

This project is strongly interconnected with several other projects supported by ONR and other federal and state agencies. The CalCOFI program provides the sampling opportunity to collect the continuous underway data and much of the supporting data used in this analysis. This project has benefited from additional sampling to study the effects of El Niño in the California Current supported by UC and NOAA. We have provided hydrographic and underway data to several programs.

PUBLICATIONS

Hayward, T. L. and E. E. Venrick 1997. Nearsurface pattern in the California Current: Coupling between physical and biological structure. Deep-Sea Research (in press).

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